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(71) Applicant(s)
Rolls-Royce plc
(Incorporated in the United Kingdom)
65 Buckingham Gate, LONDON,
SW1E 6AT, United Kingdom

(72) Inventor(s)
Ewan Fergus Thompson

(74) Agent and/or Address for Service
Rolls-Royce plc
PO Box 31, Patents Department, DERBY,
DE24 8BJ, United Kingdom

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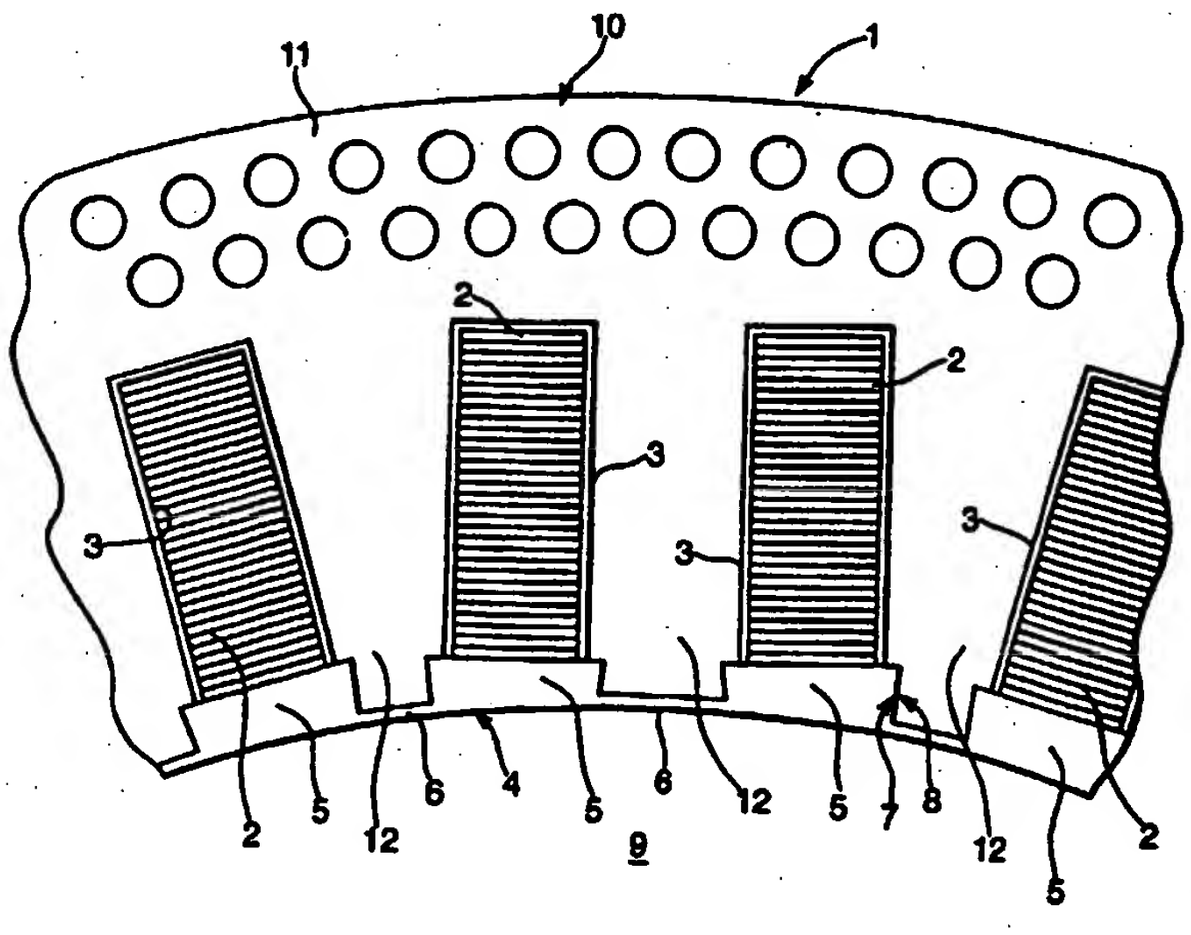
(54) Abstract Title
A liner for a fluid-cooled stator

(57) A stator assembly 1 of an electrical machine is constructed from steel plate laminations 10 with t eth 12 extending radially inwardly from an outer ring 11. Coils 2 are mounted in slots / cavities 3 between teeth 12. The slots 3 are filled with coolant fluid, and a liner 4 forms a barrier between the coolant and the interior cavity 9. The liner 4, which is made from a plastics material or a composite material such as glass reinforced plastic, comprises a barrier layer 6 and shaped elements 5 which act as resilient anchors for the liner 4. Thus, th barrier layer 6 between the elements 5 can be thin despite the low mechanical strength of the material from which the liner 4 is formed. The elements 5 are wedge shaped such that the pressure created by coolant expansion or flow, or by expansion of the coils 2 within slots 3, creates engagement between the elem nt 5 and opposed opening surfaces of each slot 3. Deformation of the barrier layer 6 is thus limited in comparison with a previously plain section cylinder liner.

Fig.2.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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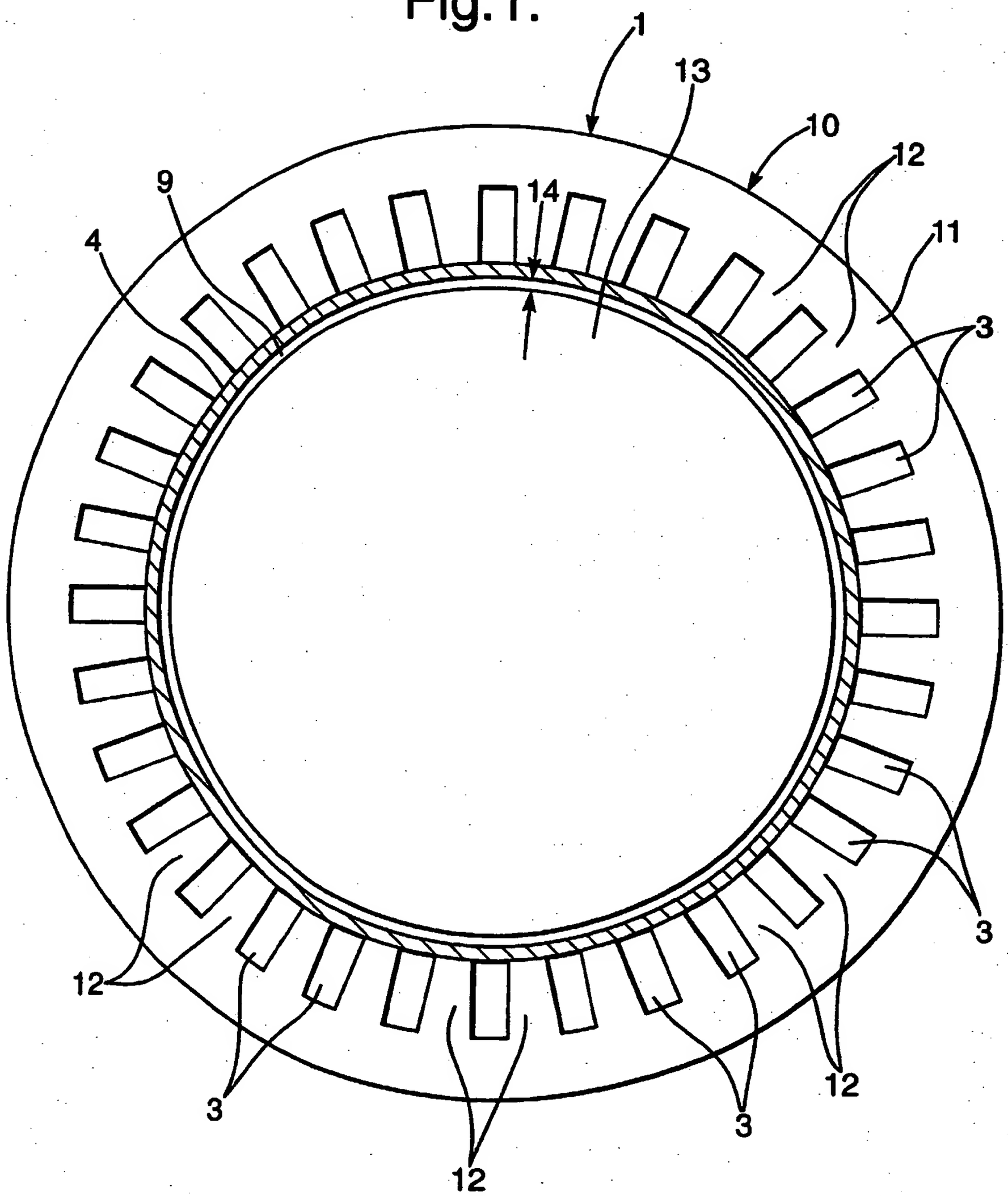
Fig.1.



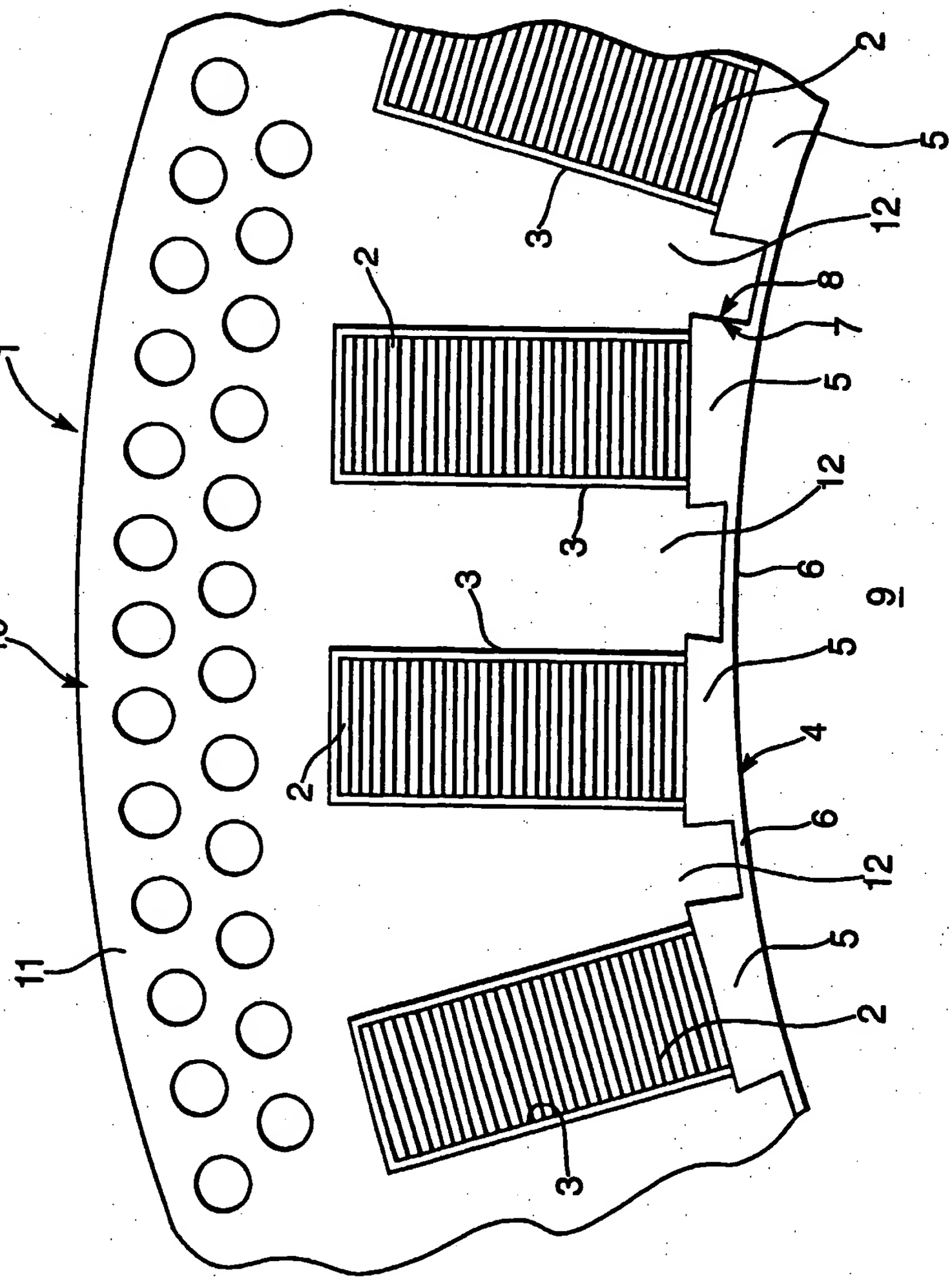


Fig.2.

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A Liner

The present invention relates to liners and more particularly to a liner used within a stator assembly of an electric machine such as an electric motor or an electric generator.

An electric machine comprises a stator assembly and a rotor. In an electric motor an electrical current supplied to the stator assembly creates rotary motion of the rotor. In an electric generator rotary motion of the rotor produces an electrical current in the stator assembly. With low power arrangements it is possible to depend upon air cooling but with higher power or higher efficiency units it is necessary to provide some form of coolant. Typically, the coolant will comprise a liquid coolant, for example, an oil or water based coolant associated with the generator or motor stator assembly, and must be separated from the rotor.

In accordance with the present invention there is provided a liner for a stator assembly bore in an electric machine, the liner comprising a barrier layer and a plurality of shaped elements, the barrier layer being at least adequate to form a barrier to fluids whilst the shaped elements are configured in use to engage respective openings in a cavity in order to reinforce the barrier layer.

Typically, the openings are in the stator coil recesses. Furthermore, and usually, the shaped elements and openings are evenly distributed.

Preferably, the liner is formed from material resistant to generation of eddy currents. Typically, the liner is made from a plastics material or composite such as glass fibre reinforced plastics material.

Preferably, the shaped elements are formed as wedges which engage their respective opening to reinforce and

resist inward displacement of the liner. Possibly, subsidiary elements or wedges are provided to augment the shaped elements integral with the barrier layer for closer conformity with respective openings. Advantageously, the shaped elements are configured to correspond with respective openings of the stator recess such that there is keyed engagement between them.

Typically, in use, each shaped element retains a respective stator coil in its stator recess cavity to allow coolant movement thereabout.

The present invention also includes an electric machine such as a motor or generator incorporating a liner as described above and subsequently.

A liner in accordance with the present invention will now be described by way of example only with reference to the accompanying drawings in which Figure 1 is a section radially through an electric machine.

Figure 2 is an enlarged schematic part section of the stator assembly of the electric machine shown in Figure 1.

In Figures 1 and 2 showing a stator assembly 1 used in an electric machine, such as a motor or generator, it will be seen that the assembly 1 incorporates a number of coils 2, normally of copper wire, arranged in cavities 3 formed as toothed recesses. These cavities 3 are created from steel plate laminations 10 with the appropriate cavity cut into each lamination and the laminations stacked to form the cavity 3. Each steel plate lamination 10 comprises a generally radially outer ring 11 and a plurality of teeth 12 extending radially inwardly from the outer ring 11. The steel plate laminations 10 are stacked coaxially and with the teeth 12 in alignment to form the cavities 3. Typically, the cavities 3 will have been machine ground for accuracy. During assembly the coils 2 may be fabricated away from the stator assembly and then slid radially outwards upon tooth centres 12 in the centre of each cavity 3. The stator cavities 3 have openings upon the inner

central side of the assembly 1. These openings are closed by a liner 4 in accordance with the pr sent invention.

The liner 4 comprises shaped elements 5 and a barrier layer 6 which extends between the elements 5 and around the inner circumference or bore cavity 9 of the stator assembly 1. The inner cavity 9 or bore of the stator assembly 1 is arranged to accommodate a rotor (not shown) of the electric machine such that there is a minimum air gap between the rotor and the inner surface of the liner 4.

As indicated above electric machines such as motors and generators are not 100% efficient such that heat energy must be dissipated by cooling particularly with higher power electrical machines. Typical coolants are fluids such as oil, water or similar liquid. Heat is generated in the coils 2 and the core as a result of electrical losses. The maximum sustained power output that can be obtained from an electrical machine incorporating a stator assembly 1 usually depends upon the peak temperature allowable for the electrical insulation material surrounding the coils 2. It is possible to provide liquid cooling in the static stator assembly with air or conductive cooling of the rotor. Such a combination may be convenient for installation as an electric machine in a gas turbine but it is a necessity to ensure segregation between the coolant liquid in the stator assembly 1 and the rotor region. This is the purpose of the stator liner 4.

Typically, each cavity 3 including coil 2 will be flooded with coolant during assembly and the liner 4 placed in position in order to create a barrier between that coolant fluid and the interior cavity 9. In order to reduce weight and to ensure there is the minimum gap between the teeth 12 and the rotor it is a desirable objective to make the liner 4 as thin as structurally possible. However, the liner 4 will generally not be made from metallic material as this will create eddy currents and so affect the performance of the electric machine. The

liner 4 will typically be made from a plastics material or composite material such as glass reinforced plastic. These materials do not have the structural strength of metal but will not generate eddy currents and are typically lighter.

Although plastics and composite materials are preferred their reduced structural strength can lead to deformation of the liner 4 when subjected to external pressure such as that of the coolant/electrical coils in the cavities 3 during operation. In accordance with the present invention the shaped elements 5 engage the openings of the cavities 3 in order to resist internal distortion and compression of the liner 4 towards the rotor in the cavity 6. It will be appreciated that due to the desirability of creating the minimum air gap between the rotor and the bottom surface of the liner 4, such distortion may create fouling between the rotor and the liner 4 with subsequent failure or drag diminishing electrical efficiency.

As shown in the drawing, typically each shaped element 5 is a wedge shape in particular a dovetail shape, keyed into the opening of the cavity 3 such that downward pressure towards the cavity 9 by pressurisation of the coolant, by the coolant expanding with temperature or the electrical coil 2 expanding with temperature is resisted by engagement between opposed shoulder surfaces 7, 8 of the shaped element 5 and of teeth 12 of the cavity 3. The wedging action of the elements 5 holds the coils 2 firmly in place, thus making the coils 2 resistant to vibration. In such circumstances, the barrier layer 6 between the shaped elements 5 is securely anchored by those elements 5 such that this layer 6 can be made much thinner than previously acceptable to resist the external pressures created by the coolant and coils 2 in the stator assembly 1. Typically, the barrier layer 6 will be significantly less than 1 mm thick in order to allow close proximity of the rotor to the stator assembly 1. Without the shaped

elements 5 such a thin layer 6 would distort under the external pressures created inwardly of the stator assembly 1 and potentially into engagement with the rotor of the electric engine. Minimising the radial gap between the rotor outside diameter and the stator bore improves power density and efficiency of an electric machine.

Manufacture of the stator assembly 1 in accordance with the present invention will typically comprise construction of the stator assembly 1 from a number of toothed steel laminations 10 in order to create the cavities 3 as required. Electrical coils typically formed from copper wire will then be fabricated and slid radially onto toothed shapes 12 in each cavity 3. The liner 4 is slid axially down the length of the stator assembly 1 within the coils 2 and then coolant is supplied into the spaces between the liner 4 and the stator assembly 1 to flood the coils 2. Each element 5 will enter a respective cavity 3 opening. Whilst sliding axially down the openings of each cavity 3 the liner 4 forces each coil 2 radially outwards and clamps them in place. The wedge action resists inward relief of the coils such that they are typically under compression and clamped in place. The present invention utilises these shaped elements 5 as relatively high strength fixing points about the circumference of the stator assembly 1 bore in order to reinforce a relatively thin barrier layer 6 therebetween. Deformation is limited to the barrier layer 6 between the shaped elements 5 in comparison with a previously plain section cylinder liner which is not anchored by the shaped elements 5 in accordance with the present invention.

The liner 4 is typically moulded or preferably machined from a thicker tube such that the shaped elements 5 and layer 6 are integral and formed from a material which is not electrically conductive.

In order to facilitate easier sliding of a stator bore liner in accordance with the present invention, integral

shaped elements can be designed to be slightly smaller than the cavity openings with which they will engage. Thus, once the liner is in plac , subsidiary shaped elements can be slid into the gap or space typically between the integral shaped element and the wall surface of the cavity opening in order to create the clamping action as described previously. Typically, the subsidiary elements will be tapped into place in order to fill the remaining space between the liner and the cavity opening. The subsidiary elements may have a greater degree of thermal expansion in order to provide a tighter clamp and grip within the cavity 3 opening as temperature increases or otherwise.

Although described with regard to an electric machine it will be appreciated that the present liner could be used to segregate two fluids at a cylindrical interface where a locally very thin non-metallic liner is required.

The liner 4 may expand as a result of temperature elevation particularly in the barrier layer 6 between the shaped elements 5. In order to accommodate such expansion the liner 4 may be slightly bowed or distorted from its operational configuration when formed but achieve its desired operational configuration when the electric machine has reached operating temperature. Furthermore, slight grooves may be cut into the rear side of the liner 4 in order to predetermine and preferentially deform the liner as a result of such expansion to the desired configuration as required. Generally, thermal expansion of the liner 4 will not be significant as a result of the relatively low temperature (circa 150°C) at which the electric machine operates. Furthermore, the barrier layer 6 between the shaped elements 5 is also very thin so that thermal expansion is or can be designed as insignificant particularly for normal electrical machine operation.

The shaped elements 5 in accordance with the present invention act as reinforcement features which increase liner 4 rigidity against external pressure for material

type without increasing the radial depth of the liner 4. Although it is preferred that the shaped elements 5 are wedge shaped as shown in the drawing it will be appreciated that the cross-section of the shaped elements 5 could be any suitable entrant shape such that shoulder portions between that shaped element and the stator cavity opening act as resilient anchors. Thus a T, hook or bell cross-section may also be used. Clearly, a narrowing in the shaped element cross-section towards the stator bore surface is preferred such that the constriction caused by external pressure increases the clamping force and so resilient location of the liner 4 between the effective mounting points created by the shaped elements.

As shown in the drawing typically the upper surface of the shaped element 5 is flat to engage the coil 2 and clamp it in place. However, this surface may be shaped to better engage an end of the coil 2, facilitate coolant flow about the coil 2 or increase abutment pressure between the surfaces 7,8 as a result of external pressure.

Respective shaped elements and stator cavity openings can be key paired so that one shaped element can only enter its respective cavity in order to achieve the desired orientation of the liner in the stator assembly.

A liner in accordance with the present invention can be used in an electric machine to separate the rotor cavity from the stator assembly or region and so prevent coolant leakage. The rotor and stator assembly interact to generate electricity or motion. The present liner allows the rotor and the stator assembly coils to be located in close proximity to improve efficiency whilst maintaining a coolant seal made from a thin section of relatively weak material.

Whilst endeavouring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any

patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.

CLAIMS

1. A liner for a stator assembly bore in an electric machine, the liner comprising a barrier layer and a plurality of shaped elements, the barrier layer being at least adequate to form a barrier to fluids whilst the shaped elements are configured in use to engage respective openings in a cavity in order to reinforce the barrier layer.

2. A liner as claimed in claim 1 wherein the liner is formed from material resistant to generation of electrical eddy currents.

3. A liner as claimed in claim 1 or claim 2 wherein the liner is made from a plastics material or composite material.

4. A liner as claimed in claims 1, 2 or 3 wherein the shaped elements are wedge shaped and engage in use through shoulder surfaces with their respective opening in order to anchor the liner in use to the bore and so reinforce and resist inward displacement of the liner.

5. A liner as claimed in any preceding claim wherein the liner includes subsidiary elements to augment the shaped elements for closer conformity with the respective openings in the bore.

6. A liner as claimed in any preceding claim wherein the shaped elements are configured to correspond with respective openings in the bore such that there is keyed engagement between respective shaped elements and openings.

7. A liner as claimed in any preceding claim wherein each shaped element is configured at one end to allow in use coolant thereabout within a cavity from which its respective opening extends.

8. A liner as claimed in any preceding claim wherein the barrier layer between shaped elements is formed with a curvature or distortion in order to accommodate thermal

expansion of the liner within the bore.

9. A liner substantially as hereinbefore described with reference to the accompanying drawing.

10. An electric machine such as an electric motor or electric generator incorporating a liner as claimed in any preceding claim.

11. An electric machine as claimed in claim 10 wherein the liner also restrains a coil in each cavity of the electric machine.

12. Any novel subject matter or combination including novel subject matter disclosed herein, whether or not within the scope of or relating to the same invention as any of the preceding claims.

INVESTOR IN PEOPLE

Application No: GB 0205481.5
Claims searched: 1 - 11

Examiner: Bill Riggs
Date f search: 31 October 2002

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): H2A (ARB2, ARB3, ARB4, ARB4B2, ARC7, ARN2B)

Int Cl (Ed.7): H02K (1/20, 3/24, 5/128, 9/00, 9/19, 9/197)

Other: Online databases: EPODOC, JAPIO, OPTICS- H2A, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2282012 A	(Jeumont Industrie) see particularly arrangement of shims 6 and jacket 8	1, 2, 3, 6 at least
X	GB 0619485 A	(BTH Co. Ltd.) see particularly tubular member 20 with integral fins 23 locked in stator slots	1, 2, 4, 6 at least
X	DE 19912136 A1	(Siemens) see particularly fig.2: 13, 15	1 at least
A	EP 0456498 A2	(GE Co.) see whole document	
X	WO 92/00627 A1	(Fanuc Ltd.) see particularly abstract and fig.2: sheet-like resin separator 26	1, 2, 3, 4, 6 at least
A	US 2001030475 A	(GE Co.) see whole document	
X	PAJ Abstract and JP2002051491 (Aisin Seiki) see abstract and fig: moulded part 5		1, 2, 3, 4, 6, 8 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.